CLAIMS:

1. A method of optically interconnecting a first station to a second station by coupling a first optical beam and a second optical beam, the first optical beam originating from the first station and being directed to the second station, the second optical beam originating from the second station and being directed to the first station, the method comprising the steps of:

(a) providing a first adaptive optical module and a second adaptive optical module;

(b) disposing the first adaptive optical module in a path of the first beam for

(i) reflecting and directing the first beam to the second adaptive optical module; and

(ii) reflecting the second beam received from the second adaptive optical module, and directing the second beam to the first station; and

(c) disposing the second adaptive optical module in a path of the second beam for

(i) reflecting and directing the second beam to the first adaptive optical module; and

(ii) reflecting the first beam received from the first adaptive optical module, and directing the first beam to the second station.

2. The method of claim 1 further comprising the step of compensating for propagation errors and wherein the first and second optical modules function in a closed-loop fashion.

3. The method of claim 2, further including the steps of:

(a) providing at least one optical tilt-focus error compensator for removing tilt and/or focus errors between the first and second beams so that the beams counter-propagate; and

(b) disposing the at least one optical tilt-focus error compensator between the first adaptive optical module and the second adaptive optical module, such that the at least one optical tilt-focus error compensator is in a light path between the first adaptive optical module and the second adaptive optical module.

4. The method of claim 3, wherein the at least one optical tilt-focus error compensator comprises a first optical tilt-focus error compensator and a second optical tilt-focus error compensator, the method further including the steps of:

(a) disposing the first optical tilt-focus error compensator between the first station and the first adaptive optical module such that the first beam passes through the first optical tilt-focus error compensator before it reaches the first adaptive optical module; and

(b) disposing the second optical tilt-focus error compensator between the second station and the second adaptive optical module such that the second beam passes through the second optical tilt-focus error compensator before it reaches the second adaptive optical module.

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5. The method of claim 4 wherein at least one of the first and second adaptive optical modules comprises an adaptive optical wavefront corrector and a wavefront error sensor.

6. The method of claim 5 wherein:

the first adaptive optical module comprises:

a first adaptive optical wavefront corrector; and

a first wavefront error sensor disposed adjacent the first adaptive optical wavefront corrector; and

the second adaptive optical module comprises:

a second adaptive optical wavefront corrector; and

a second wavefront error sensor disposed adjacent the second adaptive optical wavefront corrector.

7. The method of claim 6 wherein:

the step of reflecting and directing the first beam to the second adaptive optical module, is carried out by the first adaptive optical wavefront corrector;

after reflecting of a corrected first beam by the first adaptive optical wavefront corrector, a first part of the corrected first beam is directed to the first wavefront error sensor;

the first wavefront error sensor senses a distortion of the first beam, computes a correction, and addresses the first adaptive optical wavefront corrector to reduce the distortion of

the first beam by producing the corrected first beam after reflection of the first beam by the first adaptive optical wavefront corrector ;

after correction of the first beam, and reflection and directing of the corrected first beam by the first adaptive optical wavefront corrector, a second part of the corrected first beam is directed to the second adaptive optical wavefront corrector;

the second adaptive optical wavefront corrector reflects and directs the corrected first beam to the second station;

the step of reflecting and directing the second beam to the first adaptive optical module, is carried out by the second adaptive optical wavefront corrector;

after reflecting of a corrected second beam by the second adaptive optical wavefront corrector, a first part of the corrected second beam is directed to the second wavefront error sensor;

the second wavefront error sensor senses a distortion of the second beam, computes a correction, and addresses the second adaptive optical wavefront corrector to reduce the distortion of the second beam by producing a corrected second beam after reflection of the second beam by the second adaptive optical wavefront corrector ;

after correction of the second beam, and reflection and directing of the corrected second beam by the second adaptive optical wavefront corrector, a second part of the corrected second beam is directed to the first adaptive optical wavefront corrector; and

the first adaptive optical wavefront corrector reflects and directs the corrected second beam to the first station.

8. The method of claim 1, wherein the adaptive optical modules comprise LCLVs, liquid crystal SLMs, deformable MEMS devices, optical MEMS-based SLMs, or liquid crystal cell with transparent electrodes, or any combination thereof.

9. The method of claim 4, wherein at least one of the first and second optical tilt-focus error compensators comprises a pair of tilt mirrors or a pair of real-time crystal gratings.

10. The method of claim 5, wherein the wavefront error sensor comprises conventional shearing interferometric sensors, Shack-Hartmann (local tilt) sensors, or holographic intensity-to-phase sensors. 5/1/2001 OMP

11. A method of creating an optical link between a first and a second station for the purpose of exchanging information between the two stations, the method comprising the steps of:

(a) providing a first optical beam emanating from the first station, and a second optical beam emanating from the second station;

(b) pointing the first optical beam and the second optical beam to a common location;

(c) directing each beam into a reverse direction of the other so that each station receives the beam which emanated from the other station; and

(d) correcting propagation distortions of the first and second optical beams.

12. The method of claim 11 wherein the step of correcting propagation distortions of the first and second optical beams includes a step of planarizing the wavefronts of the first and second optical beams, the step of planarizing the first and second optical beams being carried out by at least one adaptive optical module, the at least one adaptive optical module functioning in a closed-loop fashion.

13. The method of claim 12 further including the step of compensating for tilt and focus errors of the first and second optical beams, the step of compensating for tilt and focus errors being executed by at least one optical tilt-focus error compensator.

14. The method of claim 13, wherein information is encoded onto the first optical beam at the first station, information is encoded onto the second optical beam at the second station, and wherein the first optical beam arrives at the second station as a diffraction-limited beam and delivers to the second station the information encoded onto the first optical beam at the first station, and the second optical beam arrives at the first station as a diffraction-limited beam and delivers to the first station the information encoded onto the second optical beam at the second station.

15. The method of claim 14, wherein the first and second stations comprise at least one transceiver.

16. An interconnect for optically interconnecting a first station and a second station, the interconnect comprising:

a first adaptive optical module positioned in the line of sight of the first station;

a second adaptive optical module positioned in the line of sight of the second station and in the line of sight of the first adaptive optical module.

17. The interconnect of claim 16, wherein propagation errors are corrected by the first and second adaptive optical modules, and wherein the first and second adaptive optical modules function in a closed-loop fashion.

18. The interconnect of claim 17, wherein:

the first adaptive optical module (i) directs to the second adaptive optical module, a first optical beam received from the first station, and (ii) directs to the first station, a second optical beam received from the second adaptive optical module and originating from the second station; and

the second adaptive optical module (i) directs to the first adaptive optical module, the second optical beam received from the second station, and (ii) directs to the second station, the first optical beam received from the first adaptive optical module and originating from the first station.

19. The interconnect of claim 18 further comprising at least one optical tilt-focus error compensator for removing tilt and focus errors from at least one of the first and second optical beams.

20. The interconnect of claim 19 wherein the at least one optical tilt-focus error compensator comprises a first optical tilt-focus error compensator and a second optical tilt-focus error compensator, the first optical tilt-focus error compensator being disposed between the first station and the first adaptive optical module such that the first beam passes through the first optical tilt-focus error compensator before reaching the first adaptive optical module; and the second optical tilt-focus error compensator being disposed between the second station and the second adaptive optical module such that the second beam passes through the second optical tilt-focus error compensator before reaching the second adaptive optical module.

21. The interconnect of claim 19 wherein the at least one optical tilt-focus error compensator is disposed between the first adaptive optical module and the second adaptive optical module, such that the at least one optical tilt-focus error compensator is in a light path between the first and second adaptive optical modules.

22. The interconnect of claim 20 wherein at least one of the first and second adaptive optical modules comprises an adaptive optical wavefront corrector and a wavefront error sensor.

23. The interconnect of claim 22 wherein:

the first adaptive optical module comprises:

a first adaptive optical wavefront corrector; and

a first wavefront error sensor disposed adjacent the first adaptive optical wavefront corrector; and

the second adaptive optical module comprises:

a second adaptive optical wavefront corrector; and

a second wavefront error sensor disposed adjacent the second adaptive optical wavefront corrector.

24. The interconnect of claim 23 further comprising:

a first beam splitter for splitting the first beam, the first beam splitter being disposed in a light path between the first and second adaptive optical modules; and

a second beam splitter for splitting the second beam, the second beam splitter being disposed in a light path between the first and second adaptive optical modules.

25. The interconnect of claim 24 wherein the first and second adaptive optical modules function in reflection mode.

26. The interconnect of claim 25 wherein:

the first adaptive optical wavefront corrector directs the first beam to the second adaptive optical module by reflecting a corrected first beam;

after reflecting of the corrected first beam by the first adaptive optical wavefront corrector, a first part of the corrected first beam is redirected by the first beam splitter to the first wavefront error sensor;

the first wavefront error sensor senses a distortion of the first beam, computes a correction, and addresses the first adaptive optical wavefront corrector to reduce the distortion of the first beam by producing the corrected first beam after reflection of the first beam by the first adaptive optical wavefront corrector ;

after correction of the first beam, and reflection and directing of the corrected first beam by the first adaptive optical wavefront corrector, a second part of the corrected first beam is transmitted by the first beam splitter to the second adaptive optical wavefront corrector;

the second adaptive optical wavefront corrector reflects and directs the corrected first beam to the second station;

the second adaptive optical wavefront corrector directs the second beam to the first adaptive optical module by reflecting a corrected second beam;

after reflecting of a corrected second beam by the second adaptive optical wavefront corrector, a first part of the corrected second beam is redirected by the second beam splitter to the second wavefront error sensor;

the second wavefront error sensor senses a distortion of the second beam, computes a correction, and addresses the second adaptive optical wavefront corrector to reduce the distortion of the second beam by producing a corrected second beam after reflection of the second beam by the second adaptive optical wavefront corrector ;

after correction of the second beam, and reflection and directing of the corrected second beam by the second adaptive optical wavefront corrector, a second part of the corrected second beam is transmitted by the second beam splitter to the first adaptive optical wavefront corrector; and

the first adaptive optical wavefront corrector reflects and directs the corrected second beam to the first station.

27. The interconnect of claim 24 wherein the first and second adaptive optical modules function in transmission mode.

28. The interconnect of claim 27 wherein:

the first adaptive optical wavefront corrector directs the first beam to the second adaptive optical module by transmitting a corrected first beam;

after transmission of the corrected first beam by the first adaptive optical wavefront corrector, a first part of the corrected first beam is redirected by the first beam splitter to the first wavefront error sensor;

the first wavefront error sensor senses a distortion of the first beam, computes a correction, and addresses the first adaptive optical wavefront corrector to reduce the distortion of the first beam by producing the corrected first beam after transmission of the first beam by the first adaptive optical wavefront corrector ;

after correction of the first beam, and transmission of the corrected first beam by the first adaptive optical wavefront corrector, a second part of the corrected first beam is transmitted by the first beam splitter to the second adaptive optical wavefront corrector;

the second adaptive optical wavefront corrector transmits the corrected first beam to the second station;

the second adaptive optical wavefront corrector directs the second beam to the first adaptive optical module by transmitting a corrected second beam;

after transmitting of a corrected second beam by the second adaptive optical wavefront corrector, a first part of the corrected second beam is redirected by the second beam splitter to the second wavefront error sensor;

the second wavefront error sensor senses a distortion of the second beam, computes a correction, and addresses the second adaptive optical wavefront corrector to reduce the distortion of the second beam by producing a corrected second beam after transmission of the second beam by the second adaptive optical wavefront corrector ;

after correction of the second beam, and transmission and directing of the corrected second beam by the second adaptive optical wavefront corrector, a second part of the corrected

second beam is transmitted by the second beam splitter to the first adaptive optical wavefront corrector; and

the first adaptive optical wavefront corrector transmits the corrected second beam to the first station.

29. The interconnect of claim 25, wherein propagation error correction includes planarizing at least one of the first and second optical beams.

30. The interconnect of claim 27, wherein propagation error correction includes planarizing at least one of the first and second optical beams.

31. The interconnect of claim 29, wherein information is encoded onto the first optical beam at the first station, information is encoded onto the second optical beam at the second station, and wherein the first optical beam arrives at the second station as a diffraction-limited beam and delivers to the second station the information encoded onto the first optical beam at the first station, and the second optical beam arrives at the first station as a diffraction-limited beam and delivers to the first station the information encoded onto the second optical beam at the second station.

32. The interconnect of claim 17, wherein the first and second adaptive optical modules comprise LCLVs, liquid crystal SLMs, deformable MEMS devices, optical MEMS-based SLMs, or liquid crystal cells with transparent electrodes, or any combination thereof.

33. The interconnect of claim 19, wherein the at least one optical tilt-focus error compensator comprises a pair of tilt mirrors or a pair of real-time crystal gratings.

34. The interconnect of claim 22, wherein the wavefront error sensor comprises conventional shearing interferometric sensors, Shack-Hartmann (local tilt) sensors, or holographic intensity-to-phase sensors. 5/1/2001

35. The interconnect of claim 23, wherein the first and second stations comprise at least one transceiver.

36. The interconnect of claim 18, wherein at least one of the first and second stations is a moving station, and wherein the interconnect provides for auto-tracking of the at least one moving station.

37. In an optical system, a method of compensating for propagation errors, the method comprising the steps of:

(a) providing at least one adaptive optical module;

(b) receiving an optical beam by the at least one adaptive optical module;

(c) detecting the propagation errors by the at least one adaptive optical module;

(d) computing a correction to compensate for the propagation errors;

(e) applying the correction to the received optical beam;

(f) sending a corrected optical beam by the at least one adaptive optical module.

38. The method of claim 37, wherein steps (b), (c), (d), (e), and (f) represent the steps of a closed-loop method.

39. The method of claim 38, wherein the at least one adaptive optical module comprises an adaptive optical wavefront corrector, a wavefront error sensor, and a beam splitter.

40. The method of claim 39, further including the step of addressing the adaptive optical wavefront corrector by the wavefront error sensor, after the step of computing a correction to compensate for the propagation errors and before the step of applying the correction to the received optical beam, wherein:

the step of receiving an optical beam is carried out by the adaptive optical wavefront corrector;

the step of detecting the propagation errors is carried out by the wavefront error sensor after a part of the optical beam is directed to the wavefront error sensor by the beam splitter;

the step of computing a correction is carried out by the wavefront error sensor;

the step of applying the correction to the received optical beam is carried out by the adaptive optical wavefront corrector; and

the step of sending a corrected optical beam is carried out by the adaptive optical wavefront corrector.

41. The method of claim 40, further comprising the step of compensating for tilt-focus errors with at least one tilt-focus error compensator.

42. The method of claim 41 wherein the propagation errors comprise wavefront distortions.

43. The method of claim 42 wherein compensating for propagation errors includes planarizing the optical beam.

44. The method of claim 41 wherein information modulated on the optical beam is preserved throughout steps (a), (b), (c), (d), (e), and (f), and wherein the corrected optical beam is a diffraction limited beam.

45. A method of optically interconnecting a first station to a second station by coupling a first optical beam and a second optical beam, the first optical beam originating from the first station and being directed to the second station, the second optical beam originating from the second station and being directed to the first station, the method comprising the steps of:

(a) providing an adaptive optical module;

(b) disposing the adaptive optical module in the propagation path of the first beam and in the propagation path of the second beam;

(c) reflecting and directing the first beam to the second station;

(d) reflecting and directing the second beam to the first station;

46. The method of claim 45 further comprising the step of compensating for propagation errors and wherein the adaptive optical module functions in a closed-loop fashion.

47. The method of claim 46, further including the steps of:

(e) providing a first optical tilt-focus error compensator and a second optical tilt-focus error compensator for removing tilt and/or focus errors between the first and second beams so that the beams counter-propagate;

(f) disposing the first optical tilt-focus error compensator between the first station and the adaptive optical module such that the first beam passes through the first optical tilt-focus error compensator before reaching the adaptive optical module; and

(g) disposing the second optical tilt-focus error compensator between the second station and the adaptive optical module such that the second beam passes through the second optical tilt-focus error compensator before reaching the adaptive optical module.

48. The method of claim 47 wherein the adaptive optical module comprises:

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an adaptive optical wavefront corrector having a first region and a second region;

a first wavefront error sensor disposed adjacent the first region;

a second wavefront error sensor disposed adjacent the second region;

a first beam splitter disposed in a path light of the first beam; and

a second beam splitter disposed in a path light of the second beam;

wherein,

the first wavefront error sensor senses the propagation errors of the first beam, computes a correction, and addresses the first region of the adaptive optical wavefront corrector to correct propagation errors of the first beam as the first beam is reflected by the first region of the adaptive optical wavefront corrector ; and

the second wavefront error sensor senses propagation errors of the second beam, computes a correction, and addresses the second region of the adaptive optical wavefront to correct propagation errors of the second beam as the second beam is reflected by the second region of the adaptive optical wavefront corrector.

49. The method of claim 48 wherein,

after reflecting of a corrected first beam by the first region of the adaptive optical wavefront corrector, a first part the corrected first beam is directed by the first beam splitter to the first wavefront error sensor;

after correction of the first beam, and reflection and directing of the corrected first beam by the first region of the adaptive optical wavefront corrector, a second part of the corrected first

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beam is directed by the first beam splitter to the second region of the adaptive optical wavefront corrector;

the second region of the adaptive optical wavefront corrector then reflects and directs the corrected first beam to the second station;

after reflecting of a corrected second beam by the second region of the adaptive optical wavefront corrector, a first part the corrected second beam is directed by the second beam splitter to the second wavefront error sensor;

after correction of the second beam, and reflection and directing of the corrected second beam by the second region of the adaptive optical wavefront corrector, a second part of the corrected second beam is directed by the second beam splitter to the first region of the adaptive optical wavefront corrector; and

the first region of the adaptive optical wavefront corrector then reflects and directs the corrected second beam to the first station.

50. The method of claim 49, further comprising the step of providing a plurality of reflectors, wherein the reflectors are used in (i) directing the first optical beam to the second station and the second optical beam to the first station, and (ii) directing the first part of the first beam to the first wavefront error sensor and directing the first part of the second beam to the second wavefront error sensor.

51. The method of claim 45, wherein the adaptive optical module comprise LCLVs, liquid crystal SLMs, deformable MEMS devices, optical MEMS-based SLMs, or liquid crystal cells with transparent electrodes, or any combination thereof.

52. The method of claim 47, wherein at least one of the first and second optical tilt-focus error compensators comprises a pair of tilt mirrors or a pair of real-time crystal gratings.

53. The method of claim 48, wherein the wavefront error sensor comprises conventional shearing interferometric sensors, Shack-Hartmann (local tilt) sensors, or holographic intensity-to-phase sensors. 5/1/2001

54. An interconnect for optically interconnecting a first station and a second station, the interconnect coupling a first optical beam and a second optical beam, the first optical beam originating from the first station and being directed to the second station, the second optical beam originating from the second station and being directed to the first station, the interconnect comprising:

an adaptive optical wavefront corrector positioned in the line of sight of the first station and in the line of sight of the second station, the adaptive optical wavefront corrector having a first region and a second region;

a first wavefront error sensor disposed adjacent the first region; and

a second wavefront error sensor disposed adjacent the second region;

55. The interconnect of claim 54, wherein propagation errors are corrected by the adaptive optical wavefront corrector and the first and second error sensors, the adaptive optical wavefront corrector and the first and second error sensors forming a closed-loop optical device.

56. The interconnect of claim 55 further comprising at least one optical tilt-focus error compensator for removing tilt and focus errors from at least one of the first and second optical beams.

57. The interconnect of claim 56 wherein the at least one optical tilt-focus error compensator comprises a first optical tilt-focus error compensator and a second optical tilt-focus error compensator, the first optical tilt-focus error compensator being disposed between the first station and the adaptive optical wavefront corrector such that the first beam passes through the first optical tilt-focus error compensator before reaching the first region of the adaptive optical wavefront corrector, and the second optical tilt-focus error compensator being disposed between the second station and the adaptive optical wavefront corrector such that the second beam passes through the second optical tilt-focus error compensator before reaching the second region of the adaptive optical wavefront corrector.

58. The interconnect of claim 55, wherein

the first wavefront error sensor senses the propagation errors of the first beam, computes a correction, and addresses the first region of the adaptive optical wavefront corrector to correct

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propagation errors of the first beam as the first beam is reflected by the first region of the adaptive optical wavefront corrector ; and

the second wavefront error sensor senses propagation errors of the second beam, computes a correction, and addresses the second region of the adaptive optical wavefront to correct propagation errors of the second beam as the second beam is reflected by the second region of the adaptive optical wavefront corrector.

59. The interconnect of claim 58 further comprising a first beam splitter and a second beam splitter, wherein,

after reflecting of a corrected first beam by the first region of the adaptive optical wavefront corrector, a first part the corrected first beam is directed by the first beam splitter to the first wavefront error sensor;

after correction of the first beam, and reflection and directing of the corrected first beam by the first region of the adaptive optical wavefront corrector, a second part of the corrected first beam is directed by the first beam splitter to the second region of the adaptive optical wavefront corrector;

the second region of the adaptive optical wavefront corrector then reflects and directs the corrected first beam to the second station;

after reflecting of a corrected second beam by the second region of the adaptive optical wavefront corrector, a first part of the corrected second beam is directed by the second beam splitter to the second wavefront error sensor;

after correction of the second beam, and reflection and directing of the corrected second beam by the second region of the adaptive optical wavefront corrector, a second part of the corrected second beam is directed by the second beam splitter to the first region of the adaptive optical wavefront corrector; and

the first region of the adaptive optical wavefront corrector then reflects and directs the corrected second beam to the first station.

60. The interconnect of claim 59 further comprising a plurality of reflectors, wherein the reflectors are used in (a) directing the first optical beam to the second station and the second optical beam to the first station, and (b) directing the first part of the first beam to the first wavefront error sensor and directing the first part of the second beam to the second wavefront error sensor.

61. The interconnect of claim 60, wherein propagation error correction includes planarizing at least one of the first and second optical beams.

62. The interconnect of claim 61, wherein information is encoded onto the first optical beam

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at the first station, information is encoded onto the second optical beam at the second station, and wherein the first optical beam arrives at the second station as a diffraction-limited beam and delivers to the second station the information encoded onto the first optical beam at the first station, and the second optical beam arrives at the first station as a diffraction-limited beam and delivers to the first station the information encoded onto the second optical beam at the second station.

63. The interconnect of claim 54, wherein the adaptive optical wavefront corrector comprises LCLVs, liquid crystal SLMs, deformable MEMS devices, optical MEMS-based SLMs, or liquid crystal cells with transparent electrodes, or any combination thereof.

64. The interconnect of claim 54, wherein the at least one optical tilt-focus error compensator comprises a pair of tilt mirrors or a pair of real-time crystal gratings.

65. The interconnect of claim 55, wherein the wavefront error sensor comprises conventional shearing interferometric sensors, Shack-Hartmann (local tilt) sensors, or holographic intensity-to-phase sensors. 5/1/2001 DMP

66. The interconnect of claim 55, wherein the first and second stations comprise at least one transceiver.

67. The interconnect of claim 55, wherein at least one of the first and second stations is a moving station, and wherein the interconnect provides for auto-tracking of the at least one moving station.

68. A system for coupling a first optical beam originating from a first station, and a second optical beam originating from a second station, the system comprising a pair of AO modules for directing each beam into the reverse direction of the other so that first station receives the second beam and the second station receives the first beam, the system dynamically compensating for propagation errors.